

COMPARATIVE ANALYSIS OF UNDERWEIGHT, STUNTING AND WASTING FROM BIRTH TO ONE YEAR IN RURAL INDIA

Ayub Khan¹, Hari Shankar², Priyanka Dua³

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Corresponding Author:
Mr. Ayub Khan,
Email: akhanbhu94@gmail.com

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¹Research Scholar, Department of Community Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, India

²Professor, Department of Community Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, India

³Assistant Professor, Department of Paediatrics, Heritage Institute of Medical Sciences, Varanasi, India

Abstract

Background: Infant malnutrition is a critical issue in rural India, significantly affecting children's health and development. Key indicators such as underweight, stunting, and wasting are crucial in assessing the nutritional status of children. Despite ongoing efforts, rural areas in India continue to exhibit high malnutrition rates. This study aims to analyse trends in underweight, stunting, and wasting from birth to one year of age in rural Varanasi, India, offering insights into the effectiveness of existing nutritional interventions. **Material and Methods:** This prospective follow-up study was conducted between November 2022 and February 2024, focusing on newborns in rural Varanasi. Data were collected at birth and one year of age from 150 infants, using a structured questionnaire and anthropometric measurements. The study included newborns from permanent resident mothers, with both vaginal and caesarean deliveries considered. Socio-demographic characteristics were documented, and a comparative analysis was performed. **Result:** At birth, 83.3% of infants were of normal weight, but this decreased to 58.7% by one year, with the prevalence of moderate and severe underweight rising to 23.3% and 18.0%, respectively. Stunting also showed a significant increase, with normal growth dropping from 95.3% at birth to 62.0% at one year, while moderate and severe stunting rose to 24.7% and 13.3%. Wasting improved slightly, with 80.7% of infants being in the normal range by one year, but moderate and severe wasting remained a concern. **Conclusion:** The study highlights a significant deterioration in the nutritional status of infants during the first year of life, despite improvements in some areas. The findings underscore the need for enhanced and targeted nutritional interventions, particularly during the first 1000 days of life, to prevent undernutrition and its long-term consequences.

INTRODUCTION

Infant nutrition is a crucial determinant of health and development, significantly influencing growth, cognitive function, and overall well-being. In rural India, where access to essential resources and healthcare services can be limited, addressing malnutrition and its consequences is vital for improving child health outcomes.^[1] Key indicators of nutritional status—underweight, stunting, and wasting—are critical for understanding and addressing malnutrition in these settings. Underweight reflects a child's weight relative to their age, encompassing both stunting and wasting and indicating overall nutritional deficiencies.^[2] Stunting, characterized by low height for age,

signals chronic malnutrition with long-term effects on physical and cognitive development.^[3] Wasting, defined as low weight for height, indicates acute malnutrition and is associated with higher mortality and morbidity risk.^[4]

In India, the National Family Health Survey (NFHS) provides comprehensive data on nutritional indicators across different regions. The NFHS-5 (2019-21) data reveals persistent challenges in rural areas, with significant proportions of children experiencing underweight, stunting, and wasting. According to NFHS-5, approximately 34% of children under five years of age in rural India are stunted, 20% are wasted, and 32% are underweight.^[5] These figures highlight the critical need to address malnutrition, particularly in the

early years when growth and development are most rapid.

Several studies in India have investigated the changes in undernutrition indicators such as underweight, stunting, and wasting between birth and one year of age. These studies highlight critical periods where nutritional interventions are essential to prevent the onset and progression of undernutrition. For instance, a longitudinal study conducted in rural Maharashtra found that while the prevalence of low birth weight was around 18%, the proportion of children who were underweight increased to 29% by the time they reached one year of age. Similarly, the prevalence of stunting and wasting showed significant increases during the first year of life, with stunting rising from 19% at birth to 34% at one year, and wasting increasing from 10% to 20% over the same period.^[6] Another study conducted in Uttar Pradesh reported a similar pattern, where the prevalence of underweight, stunting, and wasting all saw substantial increases within the first year of life, emphasizing the need for targeted nutritional support during this critical growth period.^[7] These findings underscore the importance of early and sustained nutritional interventions, particularly in the first 1,000 days of life, to prevent the long-term consequences of undernutrition.

Socio-economic factors, including poverty, inadequate maternal education, and limited access to healthcare and nutrition, further exacerbate these challenges.^[8] Despite ongoing government efforts and interventions, such as the Integrated Child Development Services (ICDS) and National Nutrition Mission, addressing malnutrition remains a significant public health priority.^[9]

This study aims to provide a comparative analysis of underweight, stunting, and wasting from birth to one year in rural India. By examining these indicators at two critical time points, this study seeks to identify trends and variations in nutritional status, offering valuable insights into the effectiveness of current interventions and the need for targeted strategies to combat malnutrition in these communities.

MATERIALS AND METHODS

This prospective follow-up study was conducted between November 2022 and February 2024 in the rural area of Varanasi, India, focusing on newborns delivered via caesarean section or vaginal delivery. The study received approval from the Institutional Ethics Committee of the Institute of Medical Sciences, Banaras Hindu University, under reference number dean/2022/EC/3612, dated October 20, 2022. The study included newborns whose mothers were permanent residents of the study area and who had provided written consent. Exclusion criteria included stillbirths, multiple pregnancies, newborns of mothers temporarily residing elsewhere, and those without parental consent. Data collection began with a pre-designed,

validated semi-structured questionnaire and involved measurements of weight, height, head circumference, chest circumference, and mid-arm circumference. Newborns were identified through monthly delivery lists from the community health centre in the Chhapra block, Varanasi, and eligible children were randomly selected. This study focuses on data collected at birth and one year of age, capturing initial measurements and demographic information during the first visit, as well as follow-up measurements one year later. Although the broader study involves a one-year follow-up with four additional visits at three-month intervals, the present analysis is limited to the data gathered at birth and at one year of age.

Sample size calculation

$$n_1 = \frac{(z_{1-\frac{\alpha}{2}}\sqrt{(k+1)\bar{p}(1-\bar{p})} + z_{1-\beta}\sqrt{p_0(1-p_0) + kp_1(1-p_1)})^2}{k(p_1 - p_0)^2}$$

Where

$$n_0 = kn_1, \quad \bar{p} = \frac{kp_0 + p_1}{(k+1)}$$

To determine the sample size, we considered the prevalence of acute respiratory infection (ARI) in vaginal deliveries ($p_0 = 0.25$) and an estimated relative risk ($RR = 2.78$) based on Tefera M. et al.,^[10] suggesting a prevalence of $p_1 = 0.695$ in Caesarean births. The unexposed to exposed ratio ($k = 4$) was derived from the Caesarean rate in rural India (17.6%, NFHS-5) and adjusted for a 10% non-response rate and continuity correction. Using a confidence level ($Z_{1-\alpha/2} = 1.96$) and power ($Z_{1-\beta} = 1.28$), the total sample size was calculated to be 150, with 30 in the Caesarean group and 120 in the vaginal delivery group.

RESULTS

Study outlines the socio-demographic characteristics of 150 participants, providing a detailed view of their backgrounds. The mean age of the mothers is 25.27 years (± 2.81), with the largest group having completed high school or intermediate education (52.7%). A significant majority of mothers (86.7%) are housewives, while small percentages work in government service (3.3%), private sectors (6.0%), or as skilled labourers (1.3%). Fathers have a mean age of 29.01 years (± 3.76). Their educational levels are similar, with 46.7% having completed high school or intermediate studies, and a notable 40.0% having attained graduation or higher. Fathers' occupations are more varied, with 35.3% in business, 30.0% in private sectors, 19.3% as skilled labourers, and smaller percentages in agriculture (3.3%) and government service (4.0%) [Table 1].

Religiously, the majority of families are Hindu (84.0%), with a smaller Muslim minority (16.0%). In terms of caste, 60.0% of families belong to Other Backward Classes (OBC), 22.0% to Scheduled Castes (SC), and 15.3% fall under the 'Others' category. Most families live in joint or 3rd

generation households (85.3%), with only 14.7% residing in nuclear families. Socio-economically, nearly half of the participants (48.7%) belong to Class IV, with smaller proportions in Class III (23.3%), Class V (20.7%), Class II (6.0%), and a minimal 1.3% in Class I, indicating a predominantly lower-middle and lower-class population [Table 1]. [Table 2] summarizes the characteristics of mothers and their children. The average age at menarche was 12.97 years, with an average marriage age of 21.45 years. Mothers had an average of 1.77 pregnancies, with their current birth occurring at an average age of 25.27 years. Out of 265 total pregnancies, there were 237 live births (114 males and 123 females), 10 stillbirths, and 15 children who died after birth. Additionally, there were 3 spontaneous abortions. Among 150 children, 62% had a birth interval of 1-2 years, and 54% were born to multiparous mothers. In terms of birth order, 46% were firstborns, and 42.7% were second born. Most births (86.7%) occurred at term (37-40 weeks), with 80% being normal deliveries and 20% delivered via caesarean section (CS), of which 56.7% were emergencies. Consanguineous marriages were reported by 9.3% of the mothers [Table 2].

Figure A, B & C are showing the weight for age, height for age and weight for height at birth respectively. Similarly figure D, E & F are showing weight for age, height for age and weight for height at one year of age. At birth, 83.3% of infants were of normal weight, while the prevalence of moderate underweight was 10.7% and severe underweight was 6.0%. By one year of age, the proportion of infants with normal weight decreased to 58.7%, with the prevalence of moderate underweight increasing to 23.3% and severe underweight rising to 18.0%. [Figure A & Figure D] In terms of stunting, 95.3% of infants exhibited normal growth at birth, with a prevalence of 4.0% for moderate stunting and 0.7% for severe stunting. By one year, the percentage of infants with normal growth dropped to 62.0%, while the prevalence of moderate stunting increased to 24.7% and severe stunting rose to 13.3%. [Figure B & Figure E] Regarding wasting, 68.7% of infants were within the normal range at birth, with a prevalence of 21.3% for moderate wasting and 10.0% for severe wasting. By the age of one year, the proportion of normal infants increased to 80.7%, while the prevalence of moderate wasting decreased to 10.0% and severe wasting remained at 9.3% [Figure C & Figure F].

The study reveals substantial changes in nutritional status from birth to one year among infants, highlighting significant trends in underweight,

stunting, and wasting. At birth, 83.33% of infants were of normal weight, but by one year, 29.6% of these infants had transitioned to being moderately or severely underweight, with 25.6% becoming moderately underweight and 4.0% becoming severely underweight (p=0.000). Similarly, 95.33% of infants had a normal height-for-age at birth, yet by one year, 35% had developed moderate or severe stunting, with 25.9% becoming moderately stunted and 9.1% severely stunted (p=0.000). Regarding wasting, 68.67% of infants were normal at birth, but 31.3% of those initially classified as moderately or severely wasted either worsened or failed to improve by one year. Specifically, 2.9% of initially normal infants became moderately wasted, while among those who were moderately wasted at birth, 28.1% remained in the same category, 6.3% worsened to severe wasting, and 65.6% improved to a normal status (p=0.001). These findings reveal a concerning trend where a significant proportion of infants who started with normal nutritional status deteriorated over the first year, indicating a critical need for targeted nutritional interventions and health monitoring to address and prevent worsening conditions during this pivotal developmental stage [Table 3].

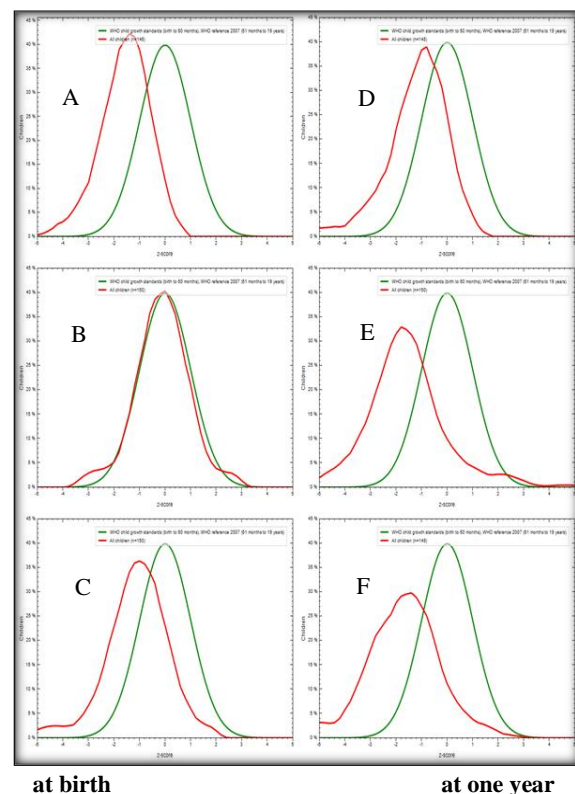


Table 1: Socio-Demographic Characteristics of Study Subjects.

Socio-Demographic Characteristics		Number(N=150)	Percentage (100%)
Mother's Age (in years)	Mean age: - 25.27 ± 2.81		
Mother's Education	Illiterate	1	0.7
	Primary & Middle	17	11.3
	High School & Intermediate	79	52.7
	Graduation & above	53	35.3

Mother's Occupation	Government Service	5	3.3
	Private	9	6.0
	Business	4	2.7
	Skilled Labourer	2	1.3
	Housewife	130	86.7
Father's Age(in years)	Mean age: - 29.01 ± 3.76		
Father's Education	Illiterate	1	0.7
	Primary & Middle	19	12.7
	High School & Intermediate	70	46.7
	Graduation & above	60	40.0
Father's Occupation	Agriculture	5	3.3
	Government Service	6	4.0
	Private	45	30.0
	Business	53	35.3
	Unskilled labourer	8	5.3
	Skilled Labourer	29	19.3
	Unemployed	4	2.7
Religion	Hindu	126	84.0
	Muslim	24	16.0
Caste	SC	33	22.0
	ST	4	2.7
	OBC	90	60.0
	Others	23	15.3
Type of Family	Nuclear	22	14.7
	Joint/3rd Generation	128	85.3
Socio-Economic Status	CLASS I	2	1.3
	CLASS II	9	6.0
	CLASS III	35	23.3
	CLASS IV	73	48.7
	CLASS V	31	20.7

Table 2: Mother & Child Characteristics

Mother's Characteristics		Mean± SD	
Age at menarche (in years)		12.97 ± 0.639	
Age at marriage (in years)		21.45 ± 1.46	
Total no. of pregnancies		265, 1.77 ± 0.87	
Age at time of current birth (in years)		25.27 ± 2.81	
Total No. of live children currently		237	
Male children		114	
Female children		123	
No. of still birth		10	
No. of children died after live births		15	
No. of spontaneous abortion		3	
Child Characteristics		N= 150	%
Birth interval	< 1 year	26	17.3
	1-2 years	93	62.0
	> 2 years	31	20.7
Parity	Nulliparous	69	46.0
	Multiparous	81	54.0
Birth order	1st order	69	46.0
	2nd order	64	42.7
	3rd & above	17	11.3
Gestation period	Pre-Term (< 37 weeks)	16	10.7
	Term (37-40 weeks)	130	86.7
	Post Term (>40 weeks)	4	2.7
Whether the delivery was CS/Vaginal/others?	CS	30	20.0
	Normal	120	80.0
If CS whether it was elective/emergency?	Elective	13	43.3
	Emergency	17	56.7
Is there any consanguineous relation with your husband before marriage?	Yes	14	9.3
	No	136	90.7

Table 3: Comparison of nutritional status at birth & one year of age

At birth	At one year			Total	McNemar-Bowker Test P value
	Normal	Underweight	Severe		
Normal	88	32	5	125	0.000*
	70.4%	25.6%	4.0%	83.33%	
Moderate	0	3	13	16	
	0.0%	18.8%	81.3%	10.67	
Severe	0	0	9	9	
	0.0%	0.0%	100.0%	6.0%	

Total	88	35	27	150	
	58.7%	23.3%	18.0%	100.0%	
Stunting					
Normal	93	37	13	143	0.000*
	65.0%	25.9%	9.1%	95.33%	
Moderate	0	0	6	6	
	0.0%	0.0%	100.0%	4.0%	
Severe	0	0	1	1	
	0.0%	0.0%	100.0%	0.67%	
Total	93	37	20	150	
	62.0%	24.7%	13.3%	100.0%	
Wasting					
Normal	100	3	0	103	0.001*
	97.1%	2.9%	0.0%	68.67%	
Moderate	21	9	2	32	
	65.6%	28.1%	6.3%	21.33%	
Severe	0	3	12	15	
	0.0%	20.0%	80.0%	10.0%	
Total	121	15	14	150	
	80.7%	10.0%	9.3%	100.0%	

DISCUSSION

The socio-demographic profile of the participants in this study provides a comprehensive view of the backgrounds of families in rural India. The mean age of mothers (25.27 years) and fathers (29.01 years) aligns with findings from other studies in similar settings, where early twenties for mothers and late twenties for fathers are typical ages for childbearing.^[11,12] In terms of educational attainment, the majority of mothers in our study had completed high school or intermediate education (52.7%), slightly higher than the national average reported by the National Family Health Survey (NFHS-5), where around 42% of women in rural India had similar educational levels.^[13] This could indicate improving educational access in the region. However, the employment status of mothers shows a strong trend towards domestic responsibilities, with 86.7% identifying as housewives. This is consistent with findings from similar rural studies, where traditional gender roles often limit women's participation in the workforce.^[14,15] For fathers, educational attainment was relatively high, with 40.0% having completed graduation or higher, surpassing national rural averages, where typically around 20-25% of men achieve this level of education.^[12] This suggests socio-economic stratification within our study population, where better-educated fathers are more likely to be engaged in business (35.3%) or private sector jobs (30.0%). These occupations reflect the diversifying employment opportunities in rural India, a trend observed in other studies from states like Tamil Nadu and Karnataka.^[16]

Religious and caste distributions in our study are reflective of broader demographic trends in rural India, where Hinduism is predominant, and the Other Backward Classes (OBC) form the majority. The caste distribution, with 60.0% belonging to OBC, aligns with data from NFHS-5, where OBC families constitute the majority in rural settings across various states.^[13] The socio-economic

classification, where nearly half of the participants belong to Class IV, is consistent with the economic profiles reported in other rural studies, indicating a predominantly lower-middle and lower-class population. The household structure in our study, where 85.3% of families live in joint or 3rd generation households, supports the enduring cultural preference for extended family living arrangements in rural India. This is corroborated by studies from other rural regions of India, where joint family systems remain prevalent. However, the small percentage of nuclear families (14.7%) could indicate a gradual shift towards smaller family units, a trend observed in rapidly urbanizing rural areas.^[17,18]

The socio-economic status of participants, with a significant portion in the lower-middle and lower classes, reflects the broader economic challenges faced by rural populations in India. Similar studies from rural Uttar Pradesh and Bihar have reported comparable socio-economic distributions, highlighting the persistent economic disparities in these regions.^[15,19]

This study highlights key characteristics of mothers and their children, providing insights into reproductive health and birth outcomes in the studied population. The average age at menarche in our study was 12.97 years, which is consistent with findings from other studies in India that report a similar mean age of menarche, generally ranging between 12.5 to 13.0 years.^[15,19] The average age at marriage was 21.45 years, aligning with national trends where early marriage is still prevalent, particularly in rural areas of India.^[14] Mothers in our study experienced an average of 1.77 pregnancies, with their current birth occurring at an average age of 25.27 years. This pattern is similar to findings from other rural studies in India, where the average number of pregnancies and the age at childbirth reflect traditional reproductive patterns (Shrivastava et al., 2013). Out of 265 total pregnancies, there were 237 live births, 10 stillbirths, and 15 postnatal deaths, with 3 spontaneous abortions. These outcomes are comparable to rates reported in similar

rural settings, indicating a significant but not unusual level of perinatal mortality.^[18]

Among the 150 children, 62% had a birth interval of 1-2 years, and 54% were born to multiparous mothers. This is consistent with research showing that shorter birth intervals and higher parity are common in rural populations, often influenced by socio-economic and cultural factors (Pandey et al., 2019). Birth order analysis revealed that 46% of the children were firstborns, and 42.7% were second-born. These figures reflect typical birth order distributions found in similar rural studies.^[16]

Most births (86.7%) occurred at term (37-40 weeks), with 80% delivered vaginally and 20% via caesarean section (CS), of which 56.7% were emergency C-sections. This distribution of delivery methods is consistent with findings from other studies in rural India, where a significant proportion of deliveries occur by caesarean section due to various factors, including maternal and fetal health conditions.^[17] Consanguineous marriages were reported by 9.3% of the mothers, a rate that aligns with findings from other rural areas of India where consanguinity remains relatively common.^[12]

This study highlights significant shifts in nutritional status from birth to one year of age among infants, focusing on underweight, stunting, and wasting. At birth, 83.3% of infants were classified as normal weight, with moderate and severe underweight rates at 10.7% and 6.0%, respectively. By one-year, normal weight infants decreased to 58.7%, with moderate and severe underweight increasing to 23.3% and 18.0%, respectively. These findings are consistent with other studies. For instance, a study in rural Tamil Nadu reported that 85.0% of infants were of normal weight at birth, with 11.5% moderately underweight and 3.5% severely underweight.²⁰ By one year, 60.0% of infants were normal weight, while moderate underweight increased to 25.0% and severe underweight to 15.0%.^[21]

Regarding stunting, this study found that 95.3% of infants exhibited normal growth at birth, with moderate and severe stunting rates at 4.0% and 0.7%, respectively. By one-year, normal growth declined to 62.0%, while moderate and severe stunting increased to 24.7% and 13.3%, respectively. These results are similar to findings from other studies. In rural Bihar, 94.0% of infants were normal at birth, with moderate and severe stunting at 5.0% and 1.0%, respectively. By one-year, normal growth fell to 65.0%, and moderate and severe stunting increased to 22.0% and 12.0%.^[19] Another study in Odisha reported that 92.0% of infants were normal at birth, with moderate and severe stunting at 6.0% and 2.0%, respectively. At one year, these rates shifted to 64.0% for normal growth, with moderate and severe stunting rising to 26.0% and 10.0%.^[22]

For wasting, this study found that 68.7% of infants were within the normal range at birth, with moderate and severe wasting rates at 21.3% and 10.0%,

respectively. By one year, the proportion of normal infants increased to 80.7%, while moderate wasting decreased to 10.0% and severe wasting remained at 9.3%. This improvement contrasts with another research from West Bengal, 65.0% of infants were normal at birth, with moderate and severe wasting at 25.0% and 10.0%, respectively. By one-year, normal wasting increased to 75.0%, with moderate wasting at 15.0% and severe wasting at 10.0%.^[23] Additionally, a study in Maharashtra showed that 70.0% of infants were normal at birth, with moderate and severe wasting at 20.0% and 10.0%, respectively. By one-year, normal wasting increased to 78.0%, while moderate and severe wasting were 12.0% and 10.0%.^[24] These findings indicate that while wasting often improves, there remains a need for ongoing nutritional support to ensure sustained health.

CONCLUSION

This study highlights the significant burden of undernutrition, particularly underweight, stunting, and wasting, among children in India from birth to one year of age. The findings indicate a considerable increase in the prevalence of these conditions during the first year of life, underscoring the critical nature of this period for child growth and development. Despite ongoing public health efforts, the persistence of high undernutrition rates suggests that existing interventions may not be sufficient to address the multifaceted causes of undernutrition in this population.

Recommendation: To address the high burden of undernutrition during the critical first 1,000 days of life, it is essential to enhance early nutritional interventions, focusing on maternal health, breastfeeding promotion, and timely complementary feeding. Regional strategies should be tailored to the needs of vulnerable populations in high-risk areas. Strengthening public health programs like ICDS and Poshan Abhiyaan through improved resources, training, and community involvement is crucial. Continuous monitoring of child growth is recommended to identify at-risk infants early and adjust interventions accordingly.

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